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Experimentation on Heat-Electricity Module from Domestic Cooking System

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ABSTRACT

Heat energy is one of the most known forms of energy. It is an efficient form of energy that possesses a lot of conversion potential into various another forms. Converted heat energy can be used for various applications. There exist some systems that release waste energy in the form of heat, which further could be utilized for useful applications. Conversion of heat into electrical energy is proving one of the efficient methods of electricity generation. TEG is the device that acts as a direct conversion medium of heat energy into electrical energy. This device is extremely reliable, safe, simple, compact and eco- friendly. The main aim of this paper is to implement the use of TEG for conversion of waste heat obtained from domestic cooking system into electrical energy and then utilizing or storing this electrical energy for various applications. This paper describes various experimentation undertaken during the hardware implementation of heat-electricity module.
Keywords : Thermoelectric generator (TEG), Conducting metal, Coolant, Copper, Ethylene Glycol.

I. INTRODUCTION

In domestic cooking gas system, the flame generated from burning of LPG is provided to utensils for the purpose of cooking of food. During cooking this flame also tends to heat surrounding space or objects. This heat which is not been used for heating the utensils is nothing but waste heat energy. Utilization of this waste heat from domestic cooking system can prove as an area of potential of electricity generation. By recovering this waste heat and then converting it into electrical energy, this waste heat could be utilized for some purposeful applications rather than letting it go waste.

In electrical engineering there are many phenomena which include generation of electricity based on heat and temperature difference. One of the components which works on this effect is Thermoelectric generator (TEG). When temperature difference is provided on the two sides of TEG, potential difference is created at its terminals. When flame passes through the gas stove burner, burner is heated and surrounding surface too. This heat is then extracted by the metal which acts as a heating surface for one side of TEG. Another side of TEG is provided cooling through a cooling material placed inside a container.

Thus, various experiments were done to finalize the size, shape and material of the conducting metal. Also, experimentations were done for selection of coolant which can provide more temperature difference to the TEG surface. In this paper detailed information about various components and materials of heat-electricity module is provided.

II. THERMOELECTRIC GENERATOR

A thermoelectric generator (TEG), is also called a Seebeck generator, is a solid-state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect.

Seebeck effect is a phenomenon in which when the two different electrical conductors or semiconductors are kept at different temperatures, the system results in the creation of electrical potential. These two dissimilar conductors are called as thermocouple. Figure below shows the Peltier plate or TEG module.

Figure 1 : Thermoelectric Generator Module

III. HEAT EXTRACTION

A. Selection of heat extracting metal:

For the purpose of heat extraction, the main consideration for selection of metal was its thermal conductivity. Therefore, search for different metals and their properties was done.

TABLE I

Thermal Conductivity of Different Metals

Sr. no	**Material**	**Thermal conductivity (w/m K)**
1	Silver	406
2	Copper	385
3	Gold	314
4	Aluminium	205
5	Brass	109
6	Iron	79.5

From the above data it was inferred that copper and aluminium could be the metals which can be taken into consideration for the intended use.

B. Finalization of selected metals:

Firstly, aluminium was preferred due to its lower cost and adequate thermal conductivity. But with the experimentation it was found that it took longer time to capture and transfer the heat with the further disadvantage of forming an amorphous scale on its surface when heated below its melting point with longer duration of time.

Then further experimentation was done with copper metal which was having better conductivity than aluminium. Also, it was observed to be more competent for longer use. Although, the cost of copper is quite higher than aluminium, its better properties compensates for its cost.

IV. COOLANT

For providing cooling to one side of TEG, experimentations were done on different types of coolant. These coolants are as follows:

1. Water
2. Oil
3. Ethylene glycol
4. Ethylene glycol mixed with water

By using these coolants following results were obtained:

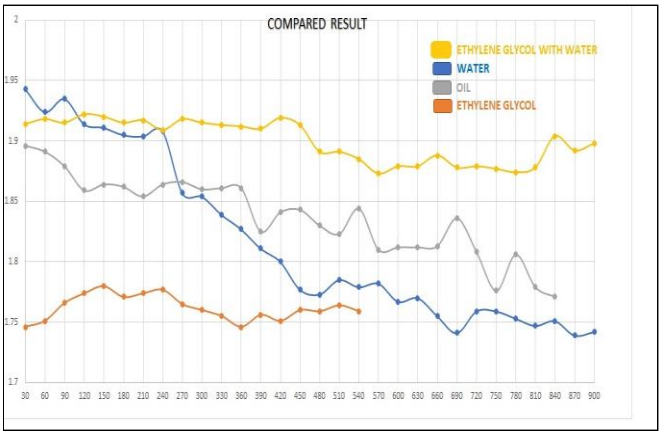

Figure 2 : Graphical representation for coolants (voltage vs time)

- As observed from the above graph, water gave maximum output at the starting but with the increase in time the output started decreasing.
- Oil gave less output than water at starting but was constant for some time then started decreasing.
- Ethylene glycol gave very less output for short duration of time than other coolants.
- The best results were obtained from ethylene glycol mixed with water (in the proportion 1:1).

It gave similar output like oil at starting and was constant throughout the time. From the observations, ethylene glycol mixed with water was found to be best coolant and was selected for the purpose of cooling.

V. MODEL DESCRIPTION

After selection of copper as heating metal and ethylene glycol mixed with water as a coolant further proceeding towards designing and fabrication is to be done.

A. Shape of conducting metal:

In order to extract heat indirectly from the burner, the top portion of the metal was so designed in a circular shape, so that it gets fit around the burner and an extra flat fin was brazed to this circular portion for mounting of TEG. Because of this brazed joint the conducting metal was not sufficiently heated even though gas stove was kept on for ample amount of time. Because of single fin two number of TEGs could be mounted on the mentioned model design.

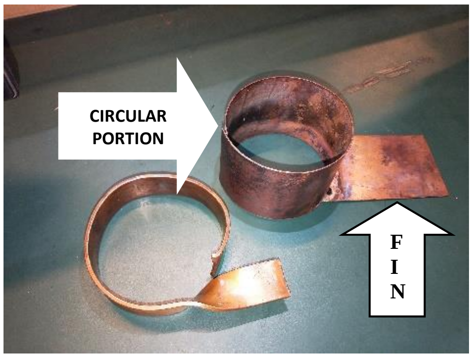

Figure 3 : Initial design of conducting metal

B. Modified Shape:

Due to some cons of previously discussed model the design was modified to have no joints. Instead, the ejection of fins was made by simply bending them at a right angle to the circular shape. In order to obtain more amount of voltage a greater number of TEGs have to be placed and to make this possible, numbers of fins is increased in this modified model.

Figure 4 : modified design of conducting metal

C. Shape of coolant container:

After provision of heating to the bottom of TEGs, now it's time to provide cooling to another side of TEGs.

For this purpose, a coolant container is chosen such that it should provide proper flat surface to the TEGs top. Also, it should contain ample volume of coolant liquid.

As per the above considerations a circular container with inlet and outlet provisions is to be designed which can facilitate changing of coolant after considerable amount of time.

VI. CONCLUSION

In this paper hardware implementation of Heat-Electricity module from domestic cooking gas system for generation of electrical energy is presented. The detailed designing aspects of conducting metal, coolant container and selection of coolant has been discussed.

After mounting of this complete assembly, the output voltage of 0.5 volts by a single TEG was obtained. Further the amount of output voltage can be increased by increasing the number of TEGs.

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